Dual-Frequency Sediment Classification in Galway Bay

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Introduction

Mapping of the coastal and marine environment is conducted for a multitude of reasons, including: to support habitat and resource management, to define sediment processes, and to monitor change. The acoustic roughness of the seabed depends on the wavelength of sound being transmitted to it. Therefore, interrogating the seabed type using more than one acoustic frequency can theoretically better distinguish different seabed types than using one frequency alone (Hughes-Clarke *et al.* 2008). The seabed of an area in Galway Bay **(Figure 1)** was classified using dual-frequency multibeam backscatter data.

Objectives

- Map the distribution of the substrate types in an area in Galway Bay.
- Paying special attention to delineating a biological substrate of environmental and commercial interest: maërl.
- Compare two approaches of sediment classification: **1) image-based processing (mosaics)** and **2) model-based analysis.**

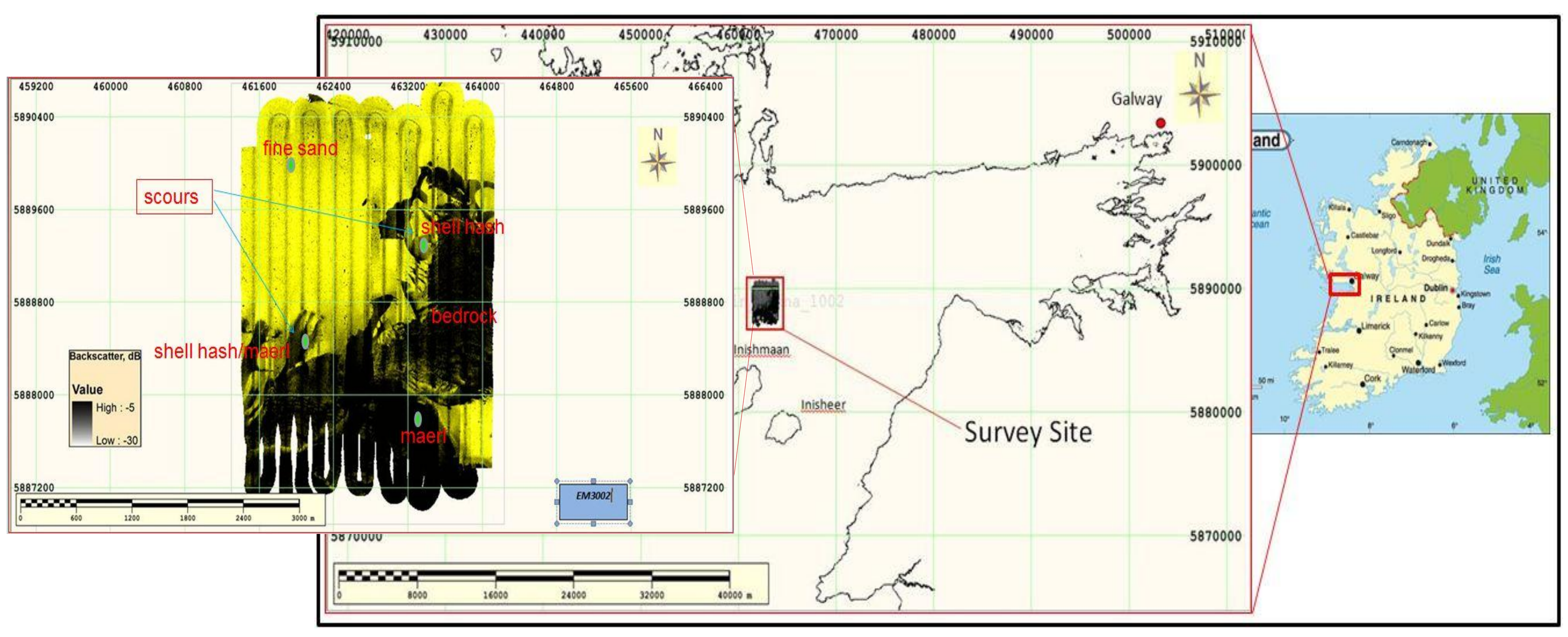

Figure 1: Survey location and sediment grab sites (indicated by green dots).

Methodology

Data Acquisition:

The data acquisition survey was carried out in September 2010 aboard the Celtic Voyager, a 31.4m research vessel. Multibeam backscatter data were acquired using the Kongsberg Simrad EM1002 and EM3002 multibeam echosounders. The area surveyed was approximately 2.7 km by 3.5 km along sixteen lines in the N-S direction. **The MBES measurements were supplemented with ground-truthing data in the form of sediment grabs taken at strategic locations (Figure 1).** The sonar records showed domains of similar backscattering strength and these various domains were sampled to check identification. These samples were sealed and frozen for further analysis **(Figure 2).**

Figure 2: The different substrates encountered, as verified by sediment grabs: maërl (left), shell hash (centre) and fine sand (right).

Results

1)Image-based processing

CARIS software was used to produce mosaics of the varying backscattering strengths of substrates on the seafloor. The backscatter data was visualised using GeoBARs (georeferenced backscatter rasters) and an angularly-corrected mosaic was then created of these GeoBARs. Using the **ArcMAP tool 'ISOCLUSTER'** mean backscattering values were assigned different colours in order to classify: (1) EM1002 and (2) EM3002 mosaics AND (3) a third image formed by compositing the EM1002 and EM3002 mosaics together **(Figure 3).**

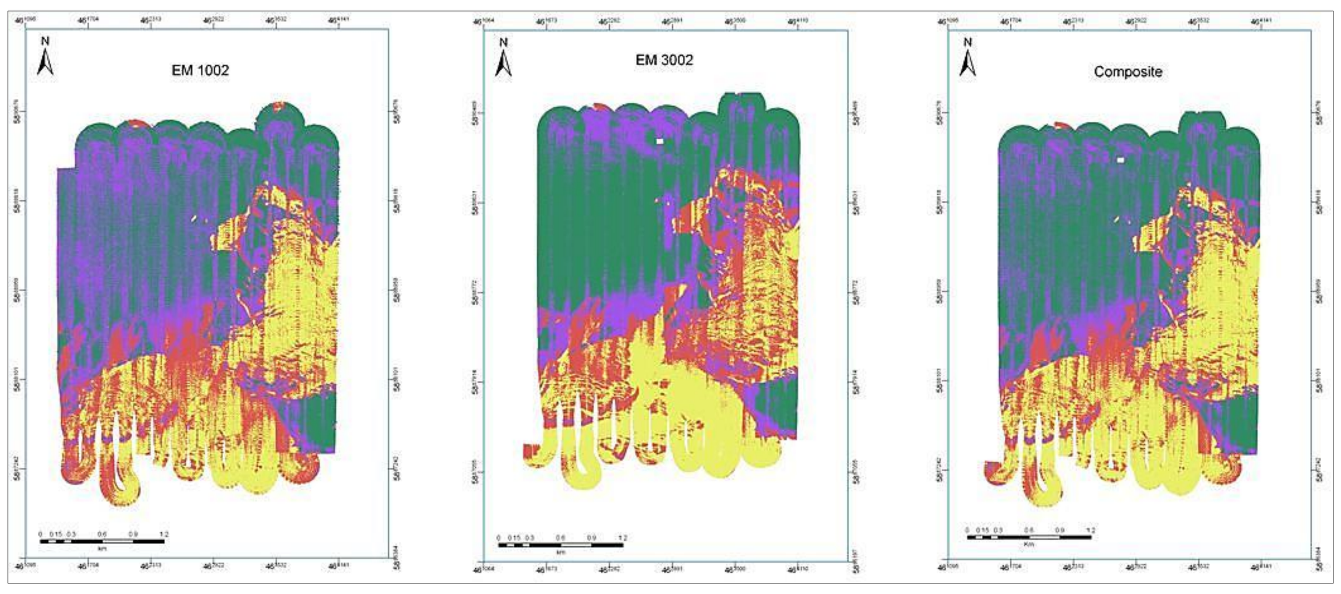

***Figure 3:** Unsupervised ISOCLUSTER Classification of EM1002 Mosaic (left); EM3002 Mosaic (centre); and Composite of EM1002 and EM3002 together (right).*

2) Model-based analysis

Geocoder is a module in CARIS that extracts modelled sediment properties, such as acoustic impedance and porosity, from analysing angular response curves of the backscatter data.

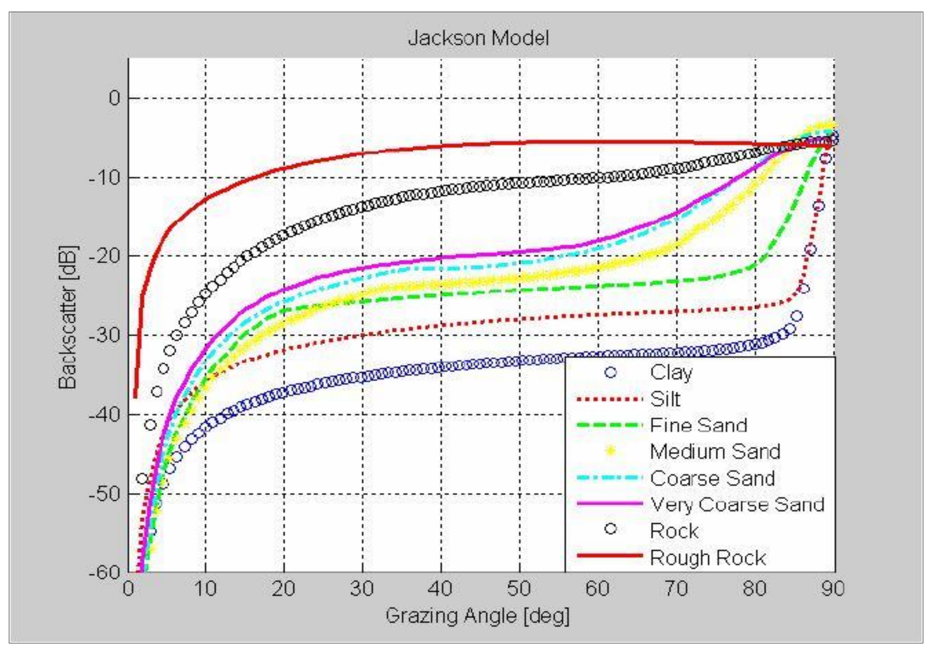

***Figure 4:** Typical characteristics of backscatter coefficients over various angles of incidence for different substrates according to Jackson's model (Jackson et al. 1986), which is used by GEOCODER to make estimations of seabed type. Source: Hempel (2007).*

The seabed was classified based on data inverted from backscatter angular response curves. **Figure 4** shows the variation of the backscatter angular response for different substrates. The given data set uses these characteristic curve progressions to estimate seafloor type.

Using the inverted model data and the Fuzzy Clustering and Data Analysis toolbox (Balasko & Feil, 2005) in **MATLAB** allowed clustering of modelled sediment properties**.** The results were displayed using **ArcMAP (Figure 5)**.

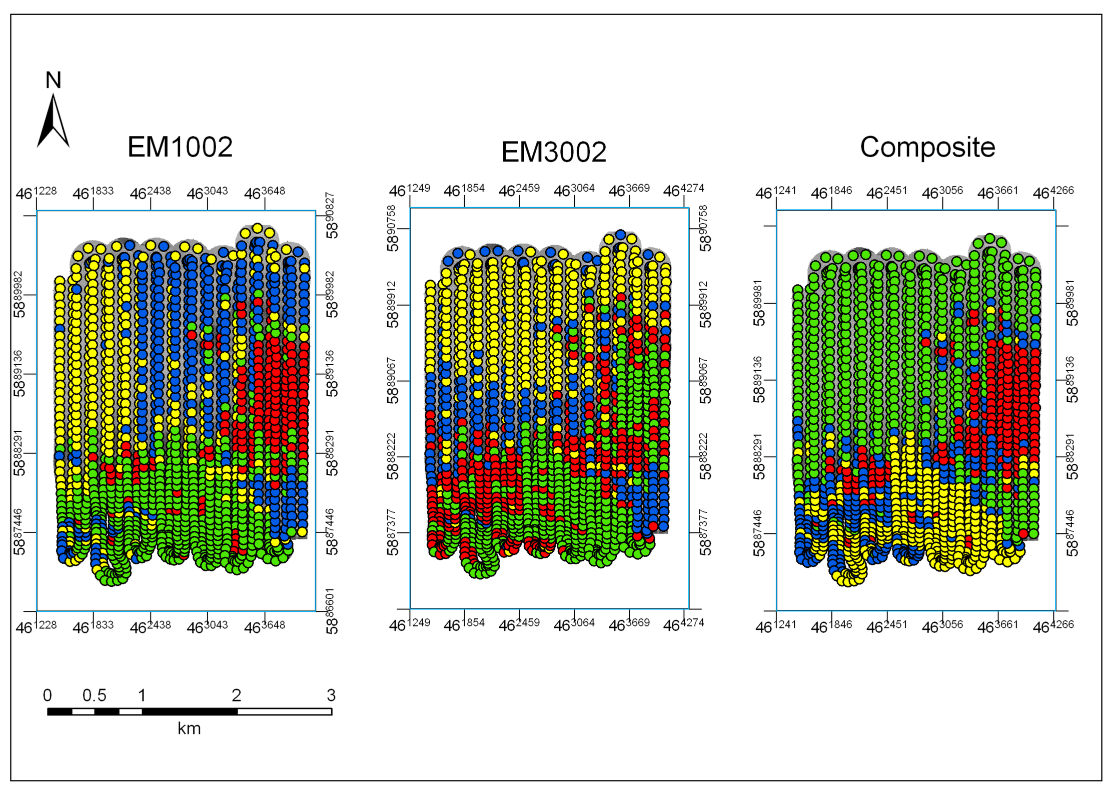

***Figure 5:** MATLAB classification of Geocoder parameters derived from: EM1002 data (left); EM3002 data (centre); and the composite of EM1002 and EM3002 together (right). In the composite image green dots correspond to fine sand, red dots correspond to bedrock and yellow dots correspond to maërl.*

Conclusion

Classification using both acoustic frequencies resulted in less noisy, more precise classes. Both classification techniques discussed have their merits: model-based analysis produces remote estimates of the geoacoustic properties of the seabed substrates; and the image-based processing produces photograph-like images, allowing the observer to readily visualise the seafloor. The classification results of the composite Geocoder data delineates between the bedrock and the maërl, whereas the classified composite image of the mosaics shows these substrates as similar (both assigned a yellow-red colour). Thus, using model-based analysis and both acoustic frequencies in conjunction with one another was the superior method. Notwithstanding the latter, this report recommends a **combinatory technique** of (a) producing unclassified backscatter mosaics to aid in seafloor visualisation and (b) classifying the seabed using model-based analysis. Refining the model-based analysis technique to automate and increase the speed of the process could have a significant impact on exploration and engineering geophysics, as it would enable a quantitative and qualitative level of seabed composition analysis that is currently inaccessible to the tools of modern science.

References:
Balasko B., Abonyi J.& Feil B. "Fuzzy Clustering and Data Analysis Toolbox: For Use with MATLAB" , 2005.
Hempel S.M. Acoustic Seafloor Classification using the Angular Backscatter Response of a Multibeam Echo Sounder. Thesis for Degree of Imaging Physics. University of Applied Sciences, Bremen, 2007.
Hughes-Clarke J, Iwanowska K, Parrott R, Duffy G, Lamplugh M, Griffin J. Inter-calibrating multi-source, multi-platform backscatter data sets to assist in compiling regional sediment type maps : Bay of Fundy. Proceedings of the Canadian Hydrographic Conference and National Surveyors Conference 2008; Pages 1-18.
Jackson D.R., Winebrenner D.P. & Ishmaru A. Application of the composite roughness model to high-frequency bottom backscattering. J Acoust Soc America 1986; 79(5):1410–22.

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